# GEOLOGY OF MADISON COUNTY.

BY

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## CONTENTS.

## INTRODUCTION.

Madison county lies in the south central part of Iowa in the third tier of counties north of Missouri. North of it is Dallas county, while to the east is Warren; to the south, Clarke and Union, and to the west, Adair. In form it is an approximate square and includes sixteen congressional townships; townships 74–77 north and ranges XXVI–XXIX west. Owing to errors in the original survey the area is only 566.4 square miles instead of the customary 576.

Geologically the county is of especial interest because of the fact that the Bethany limestone, forming the base of the Missourian formation, extends across it. An opportunity is thus afforded for a study of the relations between the productive and the non-productive portions of the coal measures. Winterset, the point at which the Bethany limestone was first studied in detail in Iowa, is the county seat and is located near the center of the county on the border between the Missourian and Des Moines stages of the Carboniferous.

In the course of his work in Iowa White spent some time in Madison county studying particularly the limestone. His

observations were published in part in 1868* and more fully in 1870.† The position and thickness of the limestone were determined, and its most characteristic fossils were noted. It does not seem that previous to this the limestone itself had ever been studied; though the higher beds of the Missourian as exposed along the Missouri river had been referred by Owen to the Sub-carboniferous, and by Geinitz, Marcou and others, in part to the same formation and in part to the Permian. More recently there has been considerable discussion in regard to the proper division of the coal measures and the correlation of the limestone found at Winterset with the Bethany limestone of Missouri and the Erie limestone of Kansas. For these reasons it has seemed desirable to make a detailed study of the outcrops which were taken by White as the type for the formation. It was hoped that data might be collected which would be of service in these broader correlations.

The work was begun some years since and in a preliminary paper‡ a section was given connecting the Winterset limestone with the Ford sandstone, the relations of which to the underlying strata had been determined by Keyes.§ In the report upon the coal deposits of the state‖ a few notes were also given on the coal beds of the county.

In the present work the authors have had the assistance both in the field and the office of Professor Calvin, and to him is due particularly the determination of the fossils. Notes on the building stones of the county collected in 1894 by Mr. Arthur C. Spencer have been freely used. While indebted to many people within the county for numerous acts of kindness, we are especially indebted to Mr. Paul Price, of Winterset, for assistance in collecting fossils. Acknowledgments are also especially due to Mr. J. A. Wilkins, of the

*First and Second Annual Reports of State Geologist, pp. 70-73. Des Moines, 1868.

†Geol. Iowa, vol. I, 241-250, 305-316. Des Moines, 1870

‡Tilton: Geological Section along Middle River in Central Iowa. Iowa Geol. Surv., vol. III, pp. 135-146. 1897.

§Bul. Geol. Soc., Am., vol. III, pp. 277-292. 1891. Also, Iowa Geol. Surv., vol. I, pp. 94, 107; vol. II.

‖Iowa Geol. Surv., vol. II, pp. 304-306. 1894.

same city, for the excellent blue print from which the accompanying map was drawn. The work as originally planned was not to be completed until the fall of 1897 but it became necessary to finish it much sooner, and in the absence of the senior author the work was completed by his associate. To this change in plan may be charged any minor omissions or lack of detail which may be noted.

## PHYSIOGRAPHY.

### TOPOGRAPHY.

Madison county lies on the eastern flank of the great divide between the Mississippi and the Missouri. The divide itself runs through Adair, the next county to the west. The area under discussion forms a portion of a much dissected upland plain, sloping to the northeast about ten feet per mile. In the southeast the high divides between the rivers rise from 950 to 975 A. T. Earlham, Winterset and Truro, all located on the upland and approximately in line, are 1,116, 1,127 and 1,078 A. T. respectively. Still further west, Stuart and Lorimer, in a line parallel to that passing through Earlham and Winterset, are respectively 1,216 and 1,230 above tide. Beyond this the surface maintains its slope to between 1,400 and 1,500 feet at Adair. This general plane, which the divides touch, is very much cut by erosion. At Bevington, Middle river has cut down to 833 A. T. At Lida, near the east county line, North river has reached 840 A. T. At Afton Junction, a short distance south of Madison county, Grand river has cut 210 feet below the upland, or to about 1,040 A. T. These three rivers drain the greater portion of the county, and the depth to which they have cut has made it possible for their many tributaries and minor feeders to cut to corresponding levels.

The land forms seen within the county are exclusively erosion forms. The later ice sheets did not extend into this area, and the length of time since the Kansan drift was deposited has been so great as to allow the streams entirely to destroy any peculiar drift topography which the county may once have had.

While the topographic forms have all been developed by erosion acting on a probably even plane, the differences in the character of the underlying rocks have been so great as to produce two distinct topographic areas. These correspond quite closely to the areas shown on the accompanying geologic map as underlain respectively by the Missourian and Des Moines formations. The former terrain, so far as this county is concerned, is made up principally of limestone. As will be seen later there are important shale beds present, but it is the limestone which controls the topography and gives it its distinctive character. The Des Moines terrain is as usual made up mainly of argillaceous and arenaceous shales, soft

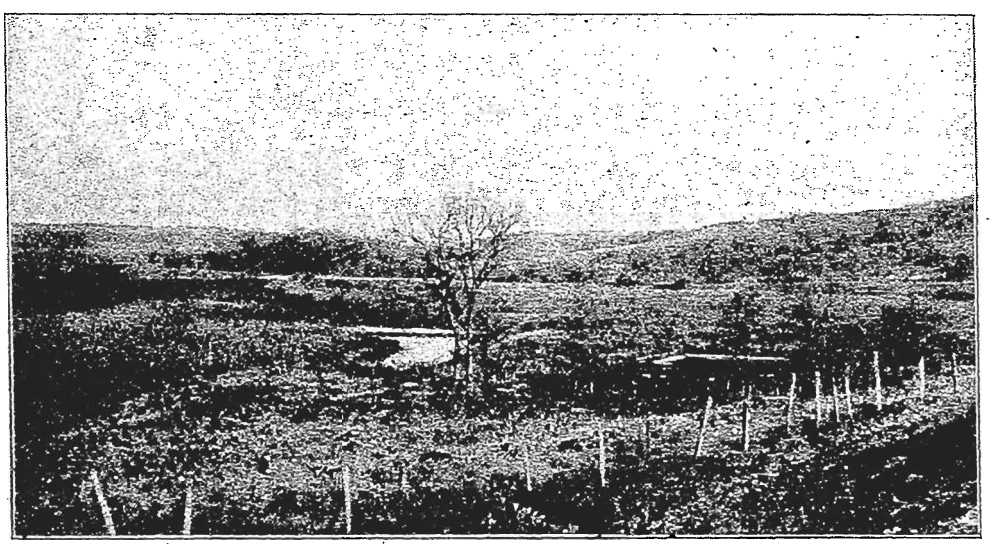


FIG 72. View down Middle river valley from a point about one mile east of Buffalo. The limestone is in the hills on either side.

sandstones, thin coal seams and easily eroded beds. There are only a few limestones, and those present are so thin as not to affect the topography to any marked extent.

As will be seen by the map, North river and Middle river have cut through the Missourian and exposed the Des Moines more than half way across the county. The minor streams, Bulger, Cedar and Jones creeks, produced results of like character, but of less extent. The valley of Clanton creek is essentially like the others in origin and character. These

valleys in the limestone country are as much as 200 feet deep and in places a mile and a half to nearly two miles wide. They have been cut by headwater erosion, and mainly by undermining of the various limestone ledges. If one travels toward the source of one of these streams, or some one of its tributaries, he will pass along a flat bottomed, canyon-like valley, until the point where the river crosses the limestone is reached. The different ledges of the latter are crossed by the stream in a series of abrupt falls or rapids. Above the latter the river becomes a mere prairie stream, with a shallow valley having gently sloping sides. In the case of the major streams the falls have been almost entirely cut away so that the crossing of the limestone is marked only by shallow rapids. The shortness of the lateral tributaries below the prairie portion and before the streams reach the region where they are uninfluenced by the limestone is worthy of notice. Some of the small streams running south from Winterset to Middle river make the whole descent of nearly 200 feet in a mile or less.

The divides between the major streamways are characteristically flat topped. Over much of this central and western portion of the county the drift is usually thin, and the streams over the upland portion have developed only the faintest relief. The limestone has sharply limited the amount of erosion that could take place over the upland, and while the time has been long—so long indeed that the whole country has been invaded and reduced to slope by feeble streams of slight grade—the relief is so little that the predominant effect is one of flatness. As one looks off over the country he sees only a broad even plain, and the semblance of a plain is preserved up almost to the brink of the wide, trough-shaped valleys which tell of the immense time through which the rivers have been at work.

In the eastern portion of the county but little of the old plain is left. The impression which a glance at the topography gives is rather one of hills and valleys. The main streams have a network of tributaries which reach out and

cut into almost every foot of intervening territory. The relief is usually 120 to 160 feet, so that large areas of level land are rare. The region east of Clanton creek forms a table land at about 1,050 to 1,075 A. T., and has been but little invaded by streams. It is held up by the underlying limestone.

Throughout most of the eastern region the action of the streams has been unhindered. The loess, drift and coal measures have approximately the same degree of hardness, and

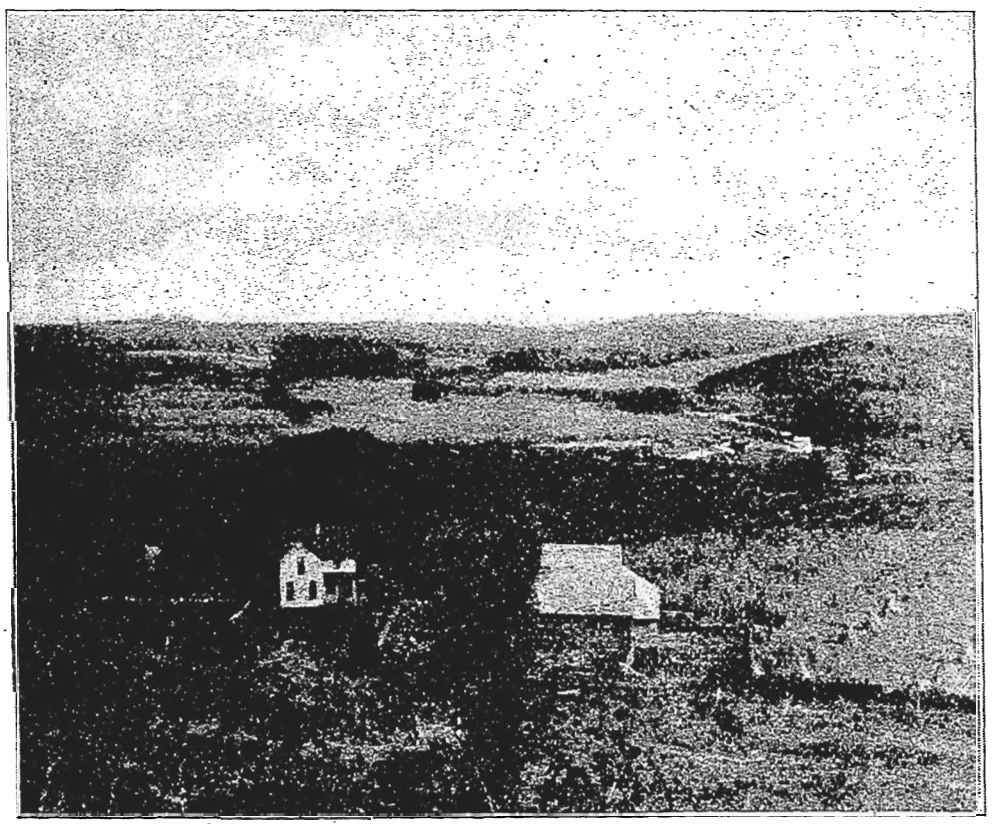


FIG. 73. View down the valley of Cedar creek in Union township (section 22), showing hill slopes of the Des Moines formation.

the profiles form continuous curves. These are usually paraboloid in character with the upper arm relatively long and showing a gentler slope. The lower portion of the curve is in most cases merged into a long gentle concave curve, which in turn passes into the almost straight slope of the river bottom land. In some instances the lower concave portion is absent, and the parabola meets the flat surface of the bottom land quite

abruptly, as if there had been recent filling in of the valley by material not derived from the sides. The valleys are broad and have well developed flood plains. The streams are not deepening their channels, and the major erosion in the county is in the western division. At places along the valleys there are the usual sloughs, marking the half-filled cut-offs left by the meandering river. In general the streams flow along the southern sides of their valleys, which is accordingly steep as compared with the long, gentle slope to the north.

### TABLE OF ELEVATIONS.

The following elevations of points within the county or near its borders have been taken in part from Gannett's Dictionary of Altitudes, and in part from the profiles of the various railway lines.

| STATION. | Altitude. | AUTHORITY. |
|---|---|---|
| Barney | 1053 | C. Gt. W. |
| Bevington | 849 | C., R. I. & P. |
| Clanton creek, north of Hanley | 878 | C. Gt. W. |
| Clanton creek, west of Barney | 1066 | C. Gt. W. |
| Earlham | 1116 | C., R. I. & P. |
| Hanley | 858 | C Gt. W. |
| Lorimer | 1230 | C. Gt W. |
| Middle river at Patterson | 854 | C., R I. & P. |
| Peru (East) | 948 | C. Gt. W. |
| Stuart | 1216 | C., R. I. & P. |
| St. Charles | 1066 | K. & W. |
| Truro | 1078 | K. & W. |
| Winterset | 1127 | C., R. I. & P. |

### DRAINAGE.

The major portion of the drainage of this county finds its way through the Des Moines to the Mississippi river. A smaller portion passes through Grand river south to the Missouri and thence to the Mississippi. The larger streams of the county are North and Middle rivers, and Clanton creek, a tributary of Middle river, which joins the larger stream in Warren county. North of the North river drainage basin is a small area, including about ten square miles, which sends its

waters through Bulger creek to the Raccoon river. Southeast of Clanton creek and beyond the Truro-St. Charles upland, is the basin of South river, including in this county thirteen and five-tenths square miles. The Grand river basin lies in the southwestern portion of the county and includes twenty-eight square miles. Of the remainder of the county North river and its branches drain 246.5 and Middle river and Clanton creek 268.4 square miles.

North river, Middle river and Clanton creek originate as prairie streams above the limestone and flowing down over

FIG. 74. View across the valley of Clanton creek toward Hanley.

the latter passes over the Des Moines formation in the broad valleys with gently sloping sides, already described. Bulger, Cedar and Jones creeks are essentially similar. Grand river flows parallel to the edge of the limestones and, throughout the county and for many miles after leaving its borders, flows over the drift. With the exception of Grand river the larger streams and many of the minor ones are flowing generally in preglacial valleys. The valley of Middle river below the "Backbone" (sections 16–15, Lincoln township), North river,

Cedar creek, Steeles branch, Jones creek, Clayton creek, Hay branch and South river all have in their valleys undisturbed drift and loess which determine their preglacial age. They do not, however, always exactly follow the older courses. Clanton creek is in a preglacial valley from Hanley to Barney, but it may be doubted whether its upper portion occupies the main part of the old channel. In sections 27 and 35 of Walnut township there is a great thickness of drift which is suggestive of a filled in valley.

Middle river has had an interesting history. The present stream had its source in the southwestern portion of Guthrie county. In its upper course in Guthrie and Adair counties it runs over the drift. In Madison county down to the locality known as the Devil's Backbone it runs generally on the drift, but occasionally cuts into the limestone in such a manner as to indicate a drift-filled valley only partially cleared. From section 21 of Lincoln township a preglacial valley, now filled with Kansan drift, extends in a winding southwesterly direction from the mouth of Fletcher branch across section 31, thence crossing westward through sections 3 and 10 of Grand River township, running south of Macksburg through sections 16, 21 and 28.* This old valley is comparable in size to the present valley of Middle river and seems, in fact, to have been its former extension, or at least the valley of an important tributary. In preglacial times Middle river accordingly drained an area to the southwest which is now served by Grand river.

Upland meanders as defined by Marbut† are excellently exhibited on Middle river. The best example is the Devil's Backbone already mentioned. The river here makes a long bend to the northward and back to within a few hundred feet of the starting point. Both above and below this point the valley is marked as usual by steep bluffs on the south and longer, gentler slopes at the north. At the Backbone this is reversed. The outside of the broad crescentic curve is

*Tilton: Proc. Iowa Acad. Sci., vol. IV, p. 51. 1897.
†Missouri Geol. Surv., vol. X, p. 93. 1896.

marked by abrupt rocky bluffs. The tongue of land around which the river runs slopes gently to the north. It is composed entirely of rock, as is well shown by the numerous exposures, so that the appearance cannot be due to filling in. In all essential particulars it agrees with the meanders described by Marbut and is similar to the Keosauqua bend illustrated by Gordon.*

The meander must have been developed *in situ*, as has been urged for similar meanders in Missouri by Winslow.† It is not to be interpreted as due to inheritance, as proposed by Davis,‡ since the two rocky sides have such markedly inequal slopes; slopes which in this instance are the exact reverse of the normal slopes throughout the region. A slight obstruction or inequality originally throwing the stream to one side set in motion the chain of processes by which the river was thrown farther and farther to the north at the same time that it cut step by step into the limestone. By constant undermining the north wall was kept steep, while by the constant shifting of the stream the south wall was preserved from similar action. It seems to have been this action, continued for a long time, which produced the broad curve and the Backbone. Clanton creek, where it crosses the limestone between Barney and Peru, shows upland meanders quite as perfect as any on Middle river.

The general character of the preglacial surface of the county may be inferred from the present topography. The drift is throughout most of the area relatively thin. At many points it is almost absent. The high, flat-topped divides and the broad, yet canyon-like valleys, were present then as now. The relief was probably somewhat greater, and in part of the county may have been as much as 300 feet. The eastern portion was then marked by less abrupt slopes, as it is now, and the southwestern portion seems to have been cut to a general altitude somewhat lower than that of the eastern edge of the limestone.

*Iowa Geol. Surv., vol. IV, plate VII. 1895.
†Science, vol. XXIII, pp. 31-32. 1893.
‡Science, vol XXII, pp. 276-279. 1893.

The time when the streams of the region originated cannot be sharply fixed. The youngest indurated rocks in the county belong to the Missourian. The Cretaceous may formerly have covered a portion of the area, though there is no direct evidence on the subject. Above the limestones of the Missourian there are only the residual clays and the drift deposits. As has been seen the region shows evidence of a former plain into which the streams have cut. It seems probable, however, that this plain could not have been a base level; at least, that it was not a base level which had required a long time for its development. There is some slight evidence in the thinning of the various limestone members of the Missourian toward the northeast that the original shore line of the Missourian seas passed through the county and that the shore deposits, very little eroded, are still preserved. If this be true, it follows that the country stood relatively low, or was, at least, preserved from great erosion from the time when the limestone rose above the sea to the cutting of the present valleys. This hypothesis is to be received with caution since it controverts supposed changes in altitude adduced from study of the surrounding counties, and is itself improbable in that it postulates a freedom from change for a longer period of time than has been usual in the earth's history.

Whenever the streams originated, they have in the main held their courses ever since. They belong to the resurrected type characteristic of the Kansan drift.* Many minor changes took place in the course of the glacial period and in recent time a considerable amount of cutting has been done. The most striking fact in relation to the drainage is its age and completeness, and while the recovery of a once completely drained area by a series of resurrected streams would be relatively rapid, these facts can only be interpreted as indicative of a very long period of time since the ice left the region.

*Bain: Iowa Geol. Surv., VI, 458-460. 1897.

## STRATIGRAPHY.

### General Relations of Strata.

The strata exposed in Madison county belong to two groups widely separated in character, origin and age. The underlying indurated rocks belong to the Carboniferous; the overlying unconsolidated beds belong to the Pleistocene. Between the two is a great unconformity indicative of a long time interval. Possibly in the drift-covered southwestern portion of the area, outliers of the Cretaceous occur between the Carboniferous and the Pleistocene. No such beds, however, have been seen in the field or reported from drill holes Fragments from the Cretaceous conglomerate seen in Guthrie county occur commonly in the drift of Madison, but at present there is no sufficient evidence for believing that the beds occur *in situ* within the limits of the county. From the close of the Carboniferous, perhaps from the early part of the Upper Carboniferous, to the oncoming of the great glaciers of the Pleistocene, Madison county seems to have been the scene of erosion rather than deposition; and yet, as has been suggested, the amount of erosion accomplished in that interval, while great as compared with that now being carried on, is small as compared with the length of the time.

The beds of the Carboniferous include rocks which make up two series of strata. The lower series is composed of sandstones, shales, coal seams and a few thin limestones. It is the Des Moines formation and includes the beds which White referred to the middle and lower coal measures. The upper series is the Missourian and is represented here by the Bethany limestone with the intercalated shales. It answers to the Upper Coal Measures of White. Both the Des Moines and the Missourian belong to the Upper Carboniferous series defined by Branner as the Pennsylvanian and currently known as the coal measures.

The Pleistocene beds include the modern alluvium, the loess and the Kansan drift sheet. An earlier drift sheet is perhaps present but has not been differentiated.

The taxonomic rank of the various formations is shown in the following table.

| GROUP. | SYSTEM. | SERIES. | STAGE. | SUB-STAGE. |
|---|---|---|---|---|
| Cenozoic. | Pleistocene. | Recent. | | Alluvium. |
| | | Glacial. | Iowan. | Loess. |
| | | | Kansan. | Drift. |
| Paleozoic. | Carboniferous. | Upper Carboniferous. (coal measures) | Missourian. | Bethany limestone. |
| | | | Des Moines | |

## Geological Formations.

### CARBONIFEROUS.

#### DES MOINES FORMATION.

The strata referred to the Des Moines are the oldest beds outcropping in the county. They underlie the eastern portion of the county and are cut into by the river valleys. Only the upper portions of the Des Moines formation outcrop within the county; the earlier beds of this stage lie below the level of the valleys of erosion. The lowest beds known in the county are probably 350 feet above the Saint Louis limestone, which lies just beneath the productive coal measures. Sections along Raccoon river by Keyes, and along Middle river by the senior author, indicate the character of the lower beds.

The Des Moines formation is characteristically a complex of shales of many kinds, sandstones, coal seams, and thin limestones. In its lower portion there is a marked lack of persistence of individual beds. The rapid and complete lithologic changes which the strata undergo have so far made it impossible to trace individual beds for any great distance. To a certain extent this is true of the upper portion of the Des

Moines formation as shown in Madison county, but in general the characteristics of individual beds persist over wide areas. In Guthrie and Dallas counties Mr. Leonard and the junior author recognize a well defined series which extends under a portion of Madison county. Farther south, however, the character of the formation changes somewhat so that it is only possible to make the most general correlations between the Des Moines beds of southeastern Madison and those farther north.

The best exposures of the Des Moines so far noted within the county may be found in South township along a stream running down to Clanton creek not far from Hanley (sections 35, 34 and 27). Starting from the Fragmental limestone, which is regarded as the base of the Bethany and exposed not far from the Des Moines & Kansas City railroad, the following section is exposed.

| | | FEET. | INCHES. |
|---|---|---|---|
| 22. | Shales, drab, argillaceous, with abundant *Derbya crassa*, *Chonetes*, probably *Chonetes parvus* Shum., at the top | 12 | |
| 21. | Shales, red, argillaceous | 3 | |
| 20. | Limestone, fragmental, earthy, with bits of fossils | | 2 |
| 19. | Shale, blue to green, argillaceous, grading into red below | 3 | |
| 18. | Shales, blue to green, sandy, with nodular segregations of limestone | 12 | |
| 17. | Shales, blue, calcareous | 12 | |
| 16. | Limestone, compact | | 2 |
| 15. | Limestone, fragmental, loose, with young *Conetes mesoloba* | | 10 |
| 14. | Limestone, fragmental, but firmly cemented, reddish color, with *Spirifer cameratus* and *Productus costatus* | 1 | |
| 13. | Shales, green, argillaceous | 29 | |
| 12. | Limestone, blue to black, in two ledges, with *Spirifer cameratus*, *Rhynchonella* and *Productus* | 1 | |
| 11. | Shale, carbonaceous | 2 | |
| 10. | Shale, clayey, drab | 1 | |
| 9. | Shale, yellow, sandy, with marked horizontal bedding planes | 4 | |
| 8. | Shales, black to drab, carbonaceous | | 6 |

| | | FEET. | INCHES. |
|---|---|---|---|
| 7. | Limestone, nodular, sandy, with *Productus cora*, *Chonetes mesoloba* and *Athyris subtilita* | 1 | 4 |
| 6. | Shale, gray, sandy | 3 | |
| 5. | Limestone, similar to number 7 | | 10 |
| 4. | Shale, clayey, drab to blue | | 10 |
| 3. | Shale, carbonaceous | 1 | |
| 2. | Limestone, thin bedded, leaf-like in texture, with *Productus muricatus*, *Chonetes mesoloba*, *Derbya crassa* and *Productus costatus* | | 3 |
| 1. | Clay, green | 3 | |

The lower portion of this section, numbers 1 to 7, is seen best on the east side of Clanton creek near Hanley (Tp. 75 N., R. XXVI W., Sec. 22), numbers 1 to 4 being seen only at this place.

Below the limestone ledges quarried north of St. Charles and belonging to the Bethany limestone, beds corresponding to numbers 14–17 of the above section are exposed at the proper horizon. The limestone (numbers 14–16) carries *Productus muricatus* and fragments of fish teeth.

Still farther north on the road leading into St. Charles from the north (South township, section 11) the following beds are exposed in a gully. The section starts 100 feet below the upland.

| | | FEET. | INCHES. |
|---|---|---|---|
| 19. | Shale, gray, clayey below, to micaceous sandy above | 30 | |
| 18. | Limestone, compact, earthy brown, with *Spirifer plano-convexus* (?) and *Spirifer cameratus* | 1 | |
| 17. | Shale, gray, argillaceous | | 8 |
| 16. | Shale, black, carbonaceous | | 6 |
| 15. | Coal, impure | | 5 |
| 14. | Shale, gray to buff, argillaceous | 4 | |
| 13. | Coal, impure | 3 | |
| 12. | Shales, gray, argillaceous | 3 | |
| 11. | Clay, yellow, ocherous, with *Productus cora* | 4 | |
| 10. | Limestone, impure, earthy, with *Productus muricatus* | 6 | |
| 9. | Shales, argillaceous, green below, red above | 3 | |

| | | FEET. | INCHES. |
|---|---|---|---|
| 8. | Limestone, dense, non-fossiliferous | | 3 |
| 7. | Shales, gray to drab, clayey | 1 | |
| 6. | Shales, black, carbonaceous, with *Productus muricatus* | 1 | |
| 5. | Limestone, fragmental | | 2 |
| 4. | Shale, gray, clayey | 2 | |
| 3. | Limestone, similar to number 5 | 1 | 6 |
| 2. | Shale, gray, clayey | 2 | |
| 1. | Limestone, soft, yellow, earthy | 8 | |

This section may be correlated, though not closely, with the Hanley section. Number 18 in the present section probably represents number 12 of that; numbers 15 and 11, numbers 13 and 8; numbers 10 and 7, numbers 8 and 5; numbers 6 and 3 and numbers 5 and 2 may be considered as equivalents. The comparison shows well the persistence and the variation in the beds of this portion of the Des Moines.

South of Patterson the exposure along a ravine (Tp. 76 N., R. XXVI W., Sec. 32, Nw. qr., Se. ¼) yields the following section:

| | | FEET. | INCHES. |
|---|---|---|---|
| 14. | Shale, black | 2 | |
| 13. | Unexposed | 21 | |
| 12. | Shale, blue, clayey above, gray, sandy below | 16 | |
| 11. | Limestone, dense, drab, fossiliferous | 1 | |
| 10. | Shale, blue, clayey | 3 | |
| 9. | Sandstone, gray | | 5 |
| 8. | Shale, clayey, blue and gray | 27 | |
| 7. | Sandstone, gray, nodular | 1 | |
| 6. | Shale, sandy, drab | 27 | |
| 5. | Limestone, arenaceous, gray, fossiliferous | | 9 |
| 4. | Shale, black | 2 | |
| 3. | Shale, gray, clayey (only partly exposed) | 30 | |
| 2. | Coal | | 6 |
| 1. | Shale, red (only partly exposed) | 32 | |

The base of this section is on a level with Middle river. The imperfect exposure of some of the beds makes its correlation difficult, but it seems probable that number 1 represents numbers 14–16 of the Hanley section.

Aside from these sections along Clanton creek and its tributaries there are occasional outcrops of Des Moines strata throughout the eastern portion of the county.

North of Tileville is a section which will be discussed later. In Lee and Jefferson townships the strata are quite generally concealed beneath the drift. They seem to consist largely of clayey and sandy shale with some sandstone. About four miles southwest of Boonville (Tp. 77 N., R. XXVIII W., Sec. 11) a two-foot layer of sandstone appears in the hillside 106 feet below the upland. Sixty feet above it is a stratum of gray sandy limestone, about two feet thick and weathering into thin layers. Similar beds may be seen farther down Badger creek in section 12 of Jefferson and sections 20 and 15 of Lee townships. The limestone is thought to be identical with that seen along the Raccoon river and numbered 13 in the following section obtained by Mr. Leonard in Dallas county (Tp. 78 N., R. XXVII W., Sec. 26, Nw. qr., Sw. ¼):

| | | FEET. | INCHES. |
|---|---|---|---|
| 15. | Drift | 6+ | |
| 14. | Sandstone, soft, gray, with flakes of yellow mica | 8 | |
| 13. | Shales, sandy, gray | 15 | |
| 12. | Limestone, sandy, fossiliferous | 1 | 2 |
| 11. | Shales, carbonaceous, coaly below | 1 | 4 |
| 10. | Shales, gray | 4 | |
| 9. | Sandstone, heavily bedded with Lepidodendrons | 4 | |
| 8. | Shale, sandy above | 6 | |
| 7. | Coal | | 6 |
| 6. | Shales, clayey, variegated | 20 | |
| 5. | Shales, bituminous | 2 | |
| 4. | Limestone, fragmentary | 5 | |
| 3. | Shales, blue to gray | 6 | |
| 2. | Shales, carbonaceous | 2 | |
| 1. | Shales, blue, clayey, exposed | 5 | |

Number 7 of this section is considered by Mr. Leonard to be the Marshall coal, and the various members of the section have been recognized along the Raccoon as far west as Guthrie county. In Madison county the limestone and coal are present in Crawford township, sections 17 and 18, and are probably represented in some of the coal horizons noted along Clanton creek. The exact correlation, however, of the

Dallas county and the Clanton creek exposures cannot be made out, and it is doubtful whether the two sections are to be considered as equivalent in other than a general way.

## MISSOURIAN FORMATION.

The beds found in Madison county which are referred to the Missourian belong entirely to the lower member, the Bethany limestone. They afford an almost complete section of that member, certain of the higher beds found on Grand river in Union county alone being lacking. The Bethany, as seen here, includes four bodies of limestone separated by shales. The complete section is well exposed on Middle river in Lincoln township, and along a ravine in section 22 the following section, which may be taken as typical, was made out.

| | | FEET. | INCHES. |
|---|---|---|---|
| 20. | Limestone, yellow, earthy, in thin layers, with Fusulina, Aulopora and *Productus semireticulatus* | 4 | |
| 19. | Shale, drab to yellowish | 1 | |
| 18. | Alternating calcareous and shaly bands, yellowish, with *Derbya crassa*, *Productus longispinus* and *Spirifer plano-convexus* | 3 | |
| 17. | Dark shale | 2 | |
| 16. | Ledge of compact limestone | 1 | 2 |
| 15. | Dark blue shale, with many crushed individuals of *Productus longispinus* | | 6 |
| 14. | Black, very carbonaceous shale | 1 | |
| 13. | Shale, argillaceous above, becoming sandy below | 4 | 6 |
| 12. | Limestone, coarse, divided by shaly partings | 3 | |
| 11. | Shale, dark, in part very carbonaceous, with band crowded with *Chonetes verneuilianus* and with occasional specimens of *Spirifer cameratus* and *Productus cora*. In places the Chonetes are cemented into a thin band of limestone | 8 | |
| 10. | Blue limestone, very fossiliferous, in three bands separated by shale | 3 | |
| 9. | Shale, dark above, lighter below | 2 | |
| 8. | Marly, yellowish shale | 3 | |

| | | FEET. | INCHES. |
|---|---|---|---|
| 7. | Yellowish, soft limestone, which becomes harder below | 5 | |
| 6. | Thin layers of limestone with shaly partings | 12 | |
| 5. | Black slate and shale | 3 | |
| 4. | Yellowish, earthy, calcareous beds showing effect of irregular deposition | 4 | |
| 3. | Limestone, with thin alternating beds of shale | 12 | |
| 2. | Black shale | 3 | |
| 1. | Band of limestone | | 6 |

At the mouth of the ravine and below number 1 of the above section is a sandy shale about fifteen feet thick shown in the lower portion of figure 75. A short distance up the

FIG 75. The Earlham limestone and underlying beds as seen in section 20 of Lincoln township.

river, at the locality known as the Devil's Backbone, beds equivalent to those enumerated are exposed. Below the shales just mentioned and forming the ledges over which the water falls is the following:

| | | FEET. | INCHES. |
|---|---|---|---|
| 4. | Limestone, thin bedded, weathering into nodular fragments | 5 | |
| 3. | Shale, parting | | 3 |
| 2. | Limestone, similar to above | 4 | |
| 1. | Shale, blue to buff, to river | 2 | |

In number 2 of this section *Athyris subtilita* occurs, being small, rather smooth, and with a feebly developed fold and sinus. In number 4 the specimens of Athyris found are larger. In number 2 *Spirifer cameratus*, *Meekella striatocostata* (small) and *Axophyllum rude* also occur.

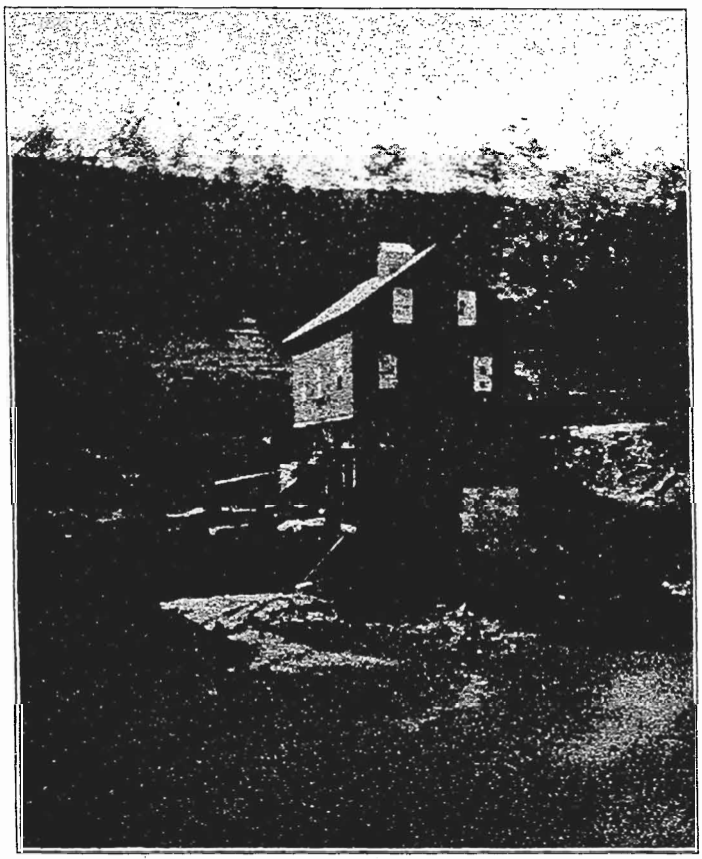


FIG. 76. The Tunnel mill at the Devil's Backbone. The main body of the limestone over the tunnel is the Earlham. That over which the water falls at the mill is the Fragmental.

The limestone forming numbers 2 and 4 of the section just given occurs at many points in Madison and adjoining counties. It forms the lowermost of the heavy limestones which mark the base of the Missourian formation and is considered to be the basal member of the Bethany. From its general character it is called the Fragmental limestone.

The first heavy limestone above the Fragmental, number 3 of the exposure in section 22, Lincoln township, is the equivalent of the beds quarried at Earlham, and hence may be called

the Earlham limestone. Numbers 6 and 7 are well exposed at Winterset, and have been extensively quarried there, so that the term Winterset, heretofore used loosely as the equivalent of Bethany, may be appropriately restricted to this horizon. Number 20 forms the base of a limestone member attaining in the vicinity a thickness of as much as twenty-five feet, and which from the abundance of Fusulina characterizing it may be called, for the present at least, the Fusulina limestone. The characteristics of these individual beds will be brought out in discussing the various exposures.

The Fragmental limestone is not well exposed in the vicinity of the Earlham quarries, though north of that place on Bear creek, Mr. Leonard has found it with the usual assemblage of fossils. In Guthrie county, just north of Stuart, it is well developed. Along a small stream emptying into Deer creek north of Stuart the basal portion of the Bethany is exposed. The lowest rock seen is the Fragmental limestone, which is made up of irregular bits of limestone filled in with calcareous shale. At one point it can be pulled to pieces with the fingers. At another it is hardened into massive (two feet) ledges. A total thickness of ten feet is seen. The fossils found include the following:

*Lophophyllum proliferum.*
*Archæocidaris, sp.?*
*Productus longespinus.*
*Orthis pecosi*
*Athyris subtilita.*
*Hustedia mormoni.*
*Spirifer lineatus*
*Spirifer cameratus.*
*Bellerophon, sp ?*
*Straparollus, sp.?*

The fauna is much like that found near St. Charles.

The Fragmental rock is seen southwest of Winterset along the ravine leading down to Middle river, but the best exposures are along Clanton creek and around the edges of the St. Charles-Truro upland. About a half mile south of Peru, on

the east side of the Chicago Great Western track, the Fragmental rock in its normal facies of loosely cemented bits of limestone is exposed twenty-four feet above Clanton creek. It carries abundant *Spirifer lineatus* and *Athyris subtilita* with frequent *Hustedia mormoni*. It is seen at several points in the vicinity, and a total thickness of ten feet is indicated. It is covered by fifteen to seventeen feet of gray shale, over which is found the Earlham limestone and the normal sequence. The rock is seen again just east of Peru in the banks of the creek and along tributaries of the main stream, and has been opened up at several points east of Hanley. At the point north of Truro (section 35, South township, at which the section of Des Moines beds already given is exposed), the Fragmental rock is found capping the Des Moines. It is here two and one-half feet thick, and is not particularly fragmental in character, but carries the following fauna:

*Productus costatus.*
*Productus longispinus.*
*Athyris subtilita.*
*Hustedia mormoni.*
*Spirifer cameratus.*
*Spirifer lineatus.*
*Spiriferina kentuckensis.*
*Rhynchonella (Pugnax) uta.*
*Dielasma bovidens.*
*Bellerophon, sp.?*
*Naticopsis, sp.?*

At the quarries north of St. Charles the rock shows the same thickness in ledges of four to six inches. The fossils found there are:

*Productus longispinus.*
*Productus costatus.*
*Athyris subtilita.*
*Hustedia mormoni.*
*Spirifer cameratus*
*Spirifer lineatus.*
*Rynchonella (Pugnax) uta.*
*Bellerophon, sp.?*

*Naticopsis altonensis.*
*Straparollus catilloides.*
*Straparollus, sp.?*

The same bed is seen southeast of St. Charles (section 1, Ohio township), and on South river (section 28). At each locality the usual assemblage of fossils, characterized by the great abundance of small, smooth specimens of *Spirifer lineatus* and *Athyris subtilita* and the comparatively rare occurrence of *Spirifer cameratus* and *Productus costatus*, was found. The fauna is one of the most characteristic, both in species, character, and relative abundance of forms found in the region, and makes an excellent guide for tracing the base of the Missourian. Near Truro and St. Charles there are no good exposures of the higher limestone, though their presence is indicated. On South river the exposures show the following section.

| | | FEET. | INCHES. |
|---|---|---|---|
| 6. | Limestone, thin bedded with *Productus cora*, and *Athyris subtilita* (large) | 2 | 6 |
| 5. | Unexposed | 6 | |
| 4. | Limestone, fragmental in part, with *Spirifer lineatus*, *Athyris subtilita* (small) *Rynchonella uta*, *Hustedia mormoni*, etc. | 3 | |
| 3. | Shale, argillaceous drab to black | 3 | |
| 2. | Unexposed | 10 | |
| 1. | Sandstone, yellow, with ripple marks and heavy cross-bedding | 6 | |

Number 6 of this section probably represents the Earlham. More limestone seems to be present in the hills, but is not exposed.

The Earlham limestone is best exposed in the quarries near the town of that name. At the Robertson quarry, two miles east of Earlham, the following section was noted:

| | | FEET. | INCHES. |
|---|---|---|---|
| 11. | Bed of soft, yellowish, magnesian, earthy limestone, decomposing readily when exposed to weather | 4 | |
| 10 | Limestone in three heavy ledges at west end of quarry | 4 | |
| 9. | Buff shale with *Chonetes verneuilianus* | | 4 |
| 8. | Limestone, like number 4 | 2 | |

| | | FEET. | INCHES. |
|---|---|---|---|
| 7. | Ashen shale with very few fragments of brachiopod shells | | 6 |
| 6. | Earthy limestone, decomposing readily, yellowish, carrying large individuals of *Athyris subtilita* | | 3 |
| 5. | Drab shale, with *Productus longispinus*, *P. costatus*, crinoid stems and fragments of other fossils | | 6 |
| 4 | Quarry limestone, in thin layers, irregularly bedded | 8 | |
| 3. | Unexposed | 20 | |
| 2. | Sandstone, in heavy layers | 7 | |
| 1 | Base of sandstone to creek, unexposed | 17 | |

At one point the quarrymen had worked down in the bottom of the quarry and exposed, below number 4, drab and black shales to the depth of three feet, and below the shales a ledge of limestone six inches in thickness.

Distributed through the limestone beds number 4 are the following:

***Lophophyllum proliferum*** McChesney.
Stem segments and body plates of crinoids.
Various species of Bryozoa.
***Meekella striatocostata*** Cox.
***Productus punctatus*** Martin.
***P. costatus*** Sowerby.
***P. longispinus*** Sowerby.
***P. cora*** D'Orbigny = *P. pattenianus* of authors.
***Athyris*** (*Seminula*) ***subtilita*** Hall.
***Hustedia mormoni*** Marcou.
***Spirifer cameratus*** Morton.
***Spiriferina kentuckensis*** Shum.
***Allorisma subcuneatum*** M. & H.

*Chonetes verneuilianus* N. & P. is somewhat common in number 9 but is very rare in the other members of the section. *Spirifer cameratus* and *Productus longispinus* are most abundant near the base of number 4, while *Productus costatus* and *Athyris subtilita* are more common in the upper layers. All the species enumerated, however, with the exception of *Allorisma subcuneatum*, range through all the beds making up number 4.

At the quarries south of Earlham in section 18, Madison township, the beds from 4 to 11 inclusive of the Robertson quarry section are exposed and are overlain by blue, drab and buff shales eight feet in thickness. The beds here carry the same fauna as the corresponding beds at the Robertson quarry.

North of Winterset the beds making up the sections seen in the quarries near Earlham are exposed along Cedar creek in section 25 of Douglass township. The beds rest on the black shale seen beneath number 4 at Robertson's quarry. The entire section is as follows:

| | | FEET. | INCHES. |
|---|---|---|---|
| 8. | Limestone, in heavy ledges | 4 | |
| 7. | Shale, buff, with very abundant *Chonetes verneulianus* | | 4 |
| 6. | Limestone, heavy bed | 2 | |
| 5. | Shale, blue, with a thin bed of reddish decomposing limestone carrying large *Athyris subtilita* | | 8 |
| 4. | Limestone, thin bedded quarry rock | 8 | |
| 3. | Shale, drab to black | 2 | |
| 2. | Limestone, dense black | 1 | |
| 1. | Shale, drab | 4 | |

Equivalent beds may be seen at several points between Earlham and Winterset. At the latter place the Earlham rock is exposed near the old lime kiln southeast of town. Along the ravine running down to Middle river the completed section is as follows:

| | | FEET. | INCHES. |
|---|---|---|---|
| 26. | Limestone, blue, Meekella zone | | 4 |
| 25. | Shale, drab to yellow | 3 | |
| 24. | Limestone, blue, three thin ledges separated by shale, *Chonetes verneulianus* very abundant | 1 | |
| 23. | Shale, drab | 1 | 3 |
| 22. | Limestone, blue | | 4 |
| 21. | Shale, drab, with very many specimens of *Derbya crassa* in and just below the limestone | 4 | |
| 20. | Limestone, earthy magnesian, easily disintegrating | 5 | |
| 19. | Shale, drab | 4 | |

| | | FEET. | INCHES. |
|---|---|---|---|
| 18. | Limestone, medium grained, coarse bedded, quarry rock | 12 | |
| 17 | Shale, clayey, drab | 2 | |
| 16. | Shale, black, slaty | 1 | |
| 15. | Shale, drab | 4 | |
| 14. | Limestone, soft, earthy | 6 | |
| 13. | Limestone, nodular, irregularly bedded | 4 | |
| 12. | Shale, yellow | | 6 |
| 11. | Limestone nodular | 4 | |
| 10. | Limestone, thin bedded with *Productus cora*, *Meekella striatocostata*, *Athyris subtilita* | 10 | |
| 9. | Shale, blue to drab | 1 | |
| 8 | Shale, black, slaty | 1 | 6 |
| 7. | Limestone, black, impure | | 6 |
| 6 | Shale, gray, clayey to sandy | 15 | |
| 5. | Limestone, fragmental | 3 | |
| 4. | Unexposed | 6– 8 | |
| 3 | Shale, gray, clayey | 1 | |
| 2. | Unexposed | 3 | |
| 1. | Limestone, fragmental | 3 | |

Of the above section numbers 1 to 5 may be referred to the Fragmental limestone. Number 10 represents the Earlham. Number 18, which has been quarried at the edge of town, the quarries being west of and above the lime kiln quarry, represents the Winterset. There is a slight dip to the west here which is at first deceptive.

The Earlham beds are seen southwest of Winterset below the old Court House quarries (section 12, Lincoln township) and again at the Backbone, where they form the heavy bed of rock above the tunnel. At this point the member attains a thickness of twenty-one feet. The thin band of shale carrying *Chonetes verneulianus* and the underlying black slate and black limestone are excellently developed. The beds are also seen along Clanton creek.

The Winterset limestone has been noted in describing the preceding sections. It is best exposed in and near Winterset and along Middle river southwest of the county seat. The beds above it and below the Fusulina limestone are of particular interest because of the abundance and perfection of the

contained fossils. Along the roadside in section 1 of Lincoln township (Sw. Sw.) large collections were made not far from the old Court House quarries. The beds exposed are the equivalents of numbers 7, 8, 10 and 11 of the typical section. The fossil-bearing horizon is limited to number 10 and the associated bands of shale. The commoner fossils, such as *Athyris subtilita*, etc., occur here in rare perfection, and associated with them are *Myalina subquadrata*, *Myalina kansasensis*, *Myalina swallowi*, *Aviculopecten occidentalis*, *Productus*

FIG. 77. The Earlham limestone, with a portion of an old lime kiln, in the southeastern portion of Winterset.

*nebrascensis* and some others not heretofore enumerated. Just above number 10 at the point where the fossils were collected, there are weathered slabs showing great numbers of individuals of a very attenuated variety of *Fusulina cylindrica*. This slender form of Fusulina may deserve to rank as a distinct species. The horizon here is below that at which *Fusulina cylindrica* attains its normal development. The

length of the individuals under consideration is about the same as that of average specimens from Montgomery county and other localities where the normal condition prevails, but the diameter is less than half that of average specimens in southwestern Iowa. Farther west, in Nebraska and neighboring states and at a slightly higher horizon, the form described as *Fusulina ventricosa* occurs. The forms at Winterset constitute an interesting term in the series showing that this Carboniferous Foraminifer, after its introduction in the lower part of the Missourian stage, became progressively more and more robust until its disappearance in the so-called Permo-Carboniferous of Nebraska and Kansas. The Fusulina limestone at the Backbone shows the following:

| | | FEET. |
|---|---|---|
| 3. | Limestone, with many Fusulina | 2 |
| 2. | Limestone, thin bedded | 13 |
| 1. | Limestone, massive ledge very full of Fusulina | 3 |

At some points in the vicinity this member attains a thickness of twenty-five feet. The lower ledge especially seems to be very constant in character, and the great abundance of the Fusulina here as compared with their number in the lower members of the Bethany makes the bed easily recognized.

As has already been suggested the upper portions of the Bethany are not exposed over the eastern portion of the county. At Tileville (Tp. 76 N., R. XXVII W., Sec. 27, Ne. qr., Sw. $\frac{1}{4}$), in a ravine running down to Cedar creek, the lower portion of the Bethany is shown as given in the following section.

| | | FEET. | INCHES. |
|---|---|---|---|
| 14. | Limestone, shaly, gray | 8 | |
| 13. | Unexposed | 6 | |
| 12. | Limestone, in thin layers | 4 | |
| 11. | Shale, clayey | 5 | |
| 10. | Limestone, bluish, dense | 1 | 2 |
| 9. | Shale, clayey, in places sandy | 1 | 2 |
| 8. | Sandstone, calcareous | | 4 |
| 7. | Shale, clayey, dark blue | 2 | 3 |
| 6. | Coal | | 1 |
| 5. | Shale, clayey | 3 | |
| 4. | Shale, red and yellow | 1 | 6 |
| 3. | Shale, sandy, gray, with reddish layer | 24 | |
| 2. | Sandstone, calcareous | 2 | 3 |
| 1. | Not exposed to Cedar creek | 57 | |

The limestones numbers 12 and 10 probably represent the base of the Bethany. They are not particularly fossiliferous and the whole section is slightly out of harmony with the stratigraphy of the neighborhood. The lack of good exposures for the present prevents the tracing of the beds to their equivalents.

## PLEISTOCENE DEPOSITS.

Over the limestones of the Missourian and the shales and sandstone of the Des Moines are the bowlder clays, sands and loess deposits which mark the action of the Pleistocene glaciers. The most notable fact with reference to these beds, as compared with the corresponding deposits of the neighboring regions, is their exceptional thinness. There are regions of thick drift, but they are unusual, particularly in the western and northwestern portion of the county, where the thinness of the drift becomes striking. In some portions of the county, as near Winterset, and between that point and Peru, the topography is strikingly like that of a driftless area. The same is true to a less extent of the region between Winterset and Earlham. The level divides, the canyon-like valleys, and the absence of the long, gentle slopes so common in the drift-covered regions, all recall, in their general aspect, the areas from which drift is absent. The frequent and abundant presence of residual clays tends to heighten the delusion. In the quarries at Earlham, and to an almost equal extent at Winterset, such clays are quite common. The red to reddish brown sticky clay which has resulted from the secular decay of the limestone, is found penetrating far down into the joint cracks and resting upon the upper surface of the rock. When shale forms the upper member of the rock series, the residual material is not so noticeable, though disintegrated shale, grading on the one hand into drift, and on the other into the undecomposed and undisturbed material, may be noted in the quarries of the Earlham Land Co. and at other points. The presence of the geest and undisturbed shale attest the feebleness of the glacial action. The ice crept in over the country,

with almost no scouring effect. In contrast with its behavior in some other portions of the country it produced here very little erosion. Its action was rather that of deposition. Nevertheless, in the deeper, sharp-walled valleys which the glaciers crossed, there seems to have been comparatively little drift deposited. Probably the relative narrowness of the valleys, their abrupt walls, and their position approximately at right angles to the major motion of the glaciers, caused them to be filled with comparatively stationary ice, while the main ice stream passed over their tops.

The deposits within the county include representatives of the Kansan drift, the loess and the alluvium. While the older Albertan or Sub-Aftonian ice sheet probably crossed the county, the deposits left by it have not so far been recognized.

## KANSAN DRIFT.

The Kansan drift is quite generally distributed throughout the county and is exposed along most of the streams. The lower part consists of a compact blue clay with small water-worn and flattened pebbles scattered through it. Where the ravines have been cut down into this clay these pebbles have often worn pot-holes, giving the otherwise smooth and rounded exposures a pitted appearance. This lower clay is best seen in the southeastern part of the county, especially southeast of Truro.

Above the blue clay is a yellowish brown layer usually two to four feet thick. In places it is much thicker. It seems to have been derived from the blue clay, the change in color resulting from the oxidation of the iron content. The clay contains numerous pebbles and bowlders. The latter consist largely of greenstone, granite and reddish quartzite, and lighter quartz rocks. These are rounded, smoothed and often well striated. Sioux quartzite is one of the most common rocks found in the drift. A block of this material is represented in figure 78. This bowlder is located a mile north of Patterson and measures ten feet long, six feet wide and five feet high,

as exposed. Such large bowlders are uncommon, but are occasionally found in the stream ways. Bowlders ordinarily are not found on the upland. It is only where the streams have cut through the loess that they appear.

Stratified sandy material is occasionally found in the drift. In general it seems to have resulted from the reworking of the drift itself, rather than to have been originally deposited in its present form. Such beds are found near Barney (Walnut township, section 35) thirty-five feet thick. Near Macks-

FIG. 78. Surface bowlder one mile south of Patterson (Tp. 76 N., R. XXVI W., sec 20, Se. qr., Sw. ¼) The rock is red quartzite, 10 feet long, 6 feet wide, and 5 feet above ground. It is said to extend 5 feet into the ground.

burg, on Grand river (Tp. 74 N., R. XXIX W., Sec. 28, Nw. qr., Nw. ¼) there is a thirty foot exposure of the same material.

## LOESS.

The loess is the surface deposit throughout the county. It spreads over upland and extends down into the valleys. It is everywhere present except where it has been cut away by recent erosion or buried beneath the alluvium. It is a light yellowish to buff, unstratified, pebbleless clay, which is highly

siliceous. Where it forms the surface the upper few inches are blackened by the admixture of humus. Elsewhere the buff color obtains. It frequently contains the calcareous concretions known as loess-kindchen.

There are two phases of the loess in the county. The upper is the one just described. Below it is frequently a darker portion, more clayey, less porous and, as contrasted with the upper, unfosiliferous. So far as observed this lower loess is characteristically free from lime nodules. In the northwestern portion of the county it forms the subsoil and is in places troublesome because of its impervious character. The two phases may be seen at the Mardis brickyard, a mile east of Winterset (Tp. 76 N., R. XXVII W., Sec. 32), and the line of separation seems to be properly correlated with the old soil seen in the railway cut at Churchville. A similar division of the loess into two phases has been observed in Warren county.* It is to be noted that the lower portion corresponds in character to the white clays of Ohio as described by Leverett, and the two phases may not improbably stand for a real and considerable difference in the age of the deposits.

## ALLUVIUM.

Alluvium is present along most of the streams of the region, but is most pronounced along the larger ones. It lies as a wash over the loess and drift which partially fills the old valleys, and in places attains a considerable thickness. West of the Winterset escarpment it is not so clayey as east of that line. Its greatest development is in the broader valleys cut in the Des Moines shales and coal measures. Along Middle river, south and west of Winterset, there is a well defined terrace rising eighteen feet above the flood plain. This seems to be an older flood plain or terrace of aggregation. Traces of similar terraces are found along certain of the other streams in the county.

*Iowa Geol. Surv., vol. V, pp. 318-356. 1896.

## ECONOMIC PRODUCTS.

### Building Stones.

Madison county is well supplied with stone suitable for various constructional purposes. The Bethany limestone includes nearly eighty feet of stone, most of which is available for one purpose or another. It is exposed in the ravines over much of the county and good quarry sites abound. As a rule but little stripping is required.

As will be seen from the general section already given there are four main bodies of limestone, designated respectively from the base to the top: (a) Fragmental, (b) Earlham, (c) Winterset quarry, (d) Fusulina. The general distribution of these beds has been already noted. Their varying thickness may be learned from the sections given. In general it may be said that they are thicker to the southwest. Some instances of their variation in this particular have been given. Each of the four members is capable of yielding good quarry rock at some point in the county, but not all are equally good at all points.

The Fragmental rock is best seen, and is exposed in its greatest thickness, at the Backbone mill, where it forms the ledge over which the water falls. At this point about nine feet of the rock is shown with only one important shale parting. The rock seems firm and should yield large blocks, but in view of its known character elsewhere in the county it is to be received with suspicion. In general the rock is very loosely cemented and breaks down readily into small nodular fragments.

The Earlham ledges are the most quarried. They yield a good grade of stone suitable for dimension work, rubble and concrete. When quarried, the Earlham is usually unprotected by overlying ledges and hence has been long exposed to weathering. As a result it is frequently badly broken up and creates a less favorable impression than the real merits of the stone warrant.

The Winterset quarry beds include those worked near Winterset and from which the stone used in the court house at that point was obtained. Their high quality is sufficiently attested by the excellent appearance of that building. The rock here used was taken from the Bevington quarry (Tp. 75 N., R. XXVIII W., Sec. 22), and certain of the layers tested at the Rock Island arsenal in 1881 showed a crushing strength of 4,588 pounds per square inch. The specific gravity of the rock was 2.73 and the ratio of absorption .042603. Stone from these beds rarely reaches the market at present, as the quarries have not been opened up except at Winterset and it requires a long haul over hilly roads to reach the railway at this place.

The Fusulina limestone is best exposed at the Backbone and seems capable of yielding excellent stone. At this locality compact ledges two and one-half to three feet in thickness may be obtained. Farther southwest the member attains a thickness of twenty-five to thirty feet. At Peru in the Reed quarry about fifteen feet are found. The stone here is thinner bedded than in the western outcrops.

In the main the quarry industry is concentrated around three points, Earlham, Winterset and Peru. The first has the advantage of location on the main line of the Chicago, Rock Island & Pacific railway, with a down grade haul of about thirty miles to Des Moines. As a result considerable quantities of stone, mainly crushed for concrete work, are marketed in the capital city. Winterset, on a branch line of the same road, is farther from market and suffers the disadvantage of less favorable freight rates. The quarries now open near this city are not so well located for connecting with the railway as at Earlham, but if the projected road southwest from Winterset be built, many excellent quarry sites will become available, and a large amount of stone can be placed on the market. At Peru and Barney the quarries are located near the Chicago Great Western but have no track facilities, so that a short wagon haul is necessary. The stone now quarried at Peru is so high in the

bluffs, seventy-four feet above the station, that a track to the quarries would not be practicable. The lower (Earlham) ledges occur not far above the level of the track, but to open them up it would be necessary to work out the overlying ledges as well. This would require considerable stripping and the handling of all the shales between the various ledges. It is doubtful whether such work would pay, certainly not without ample capital and an extensive plant. For the present only the best ledges can be marketed, as the poorer stone will not warrant the wagon haul and must be thrown on the dumps.

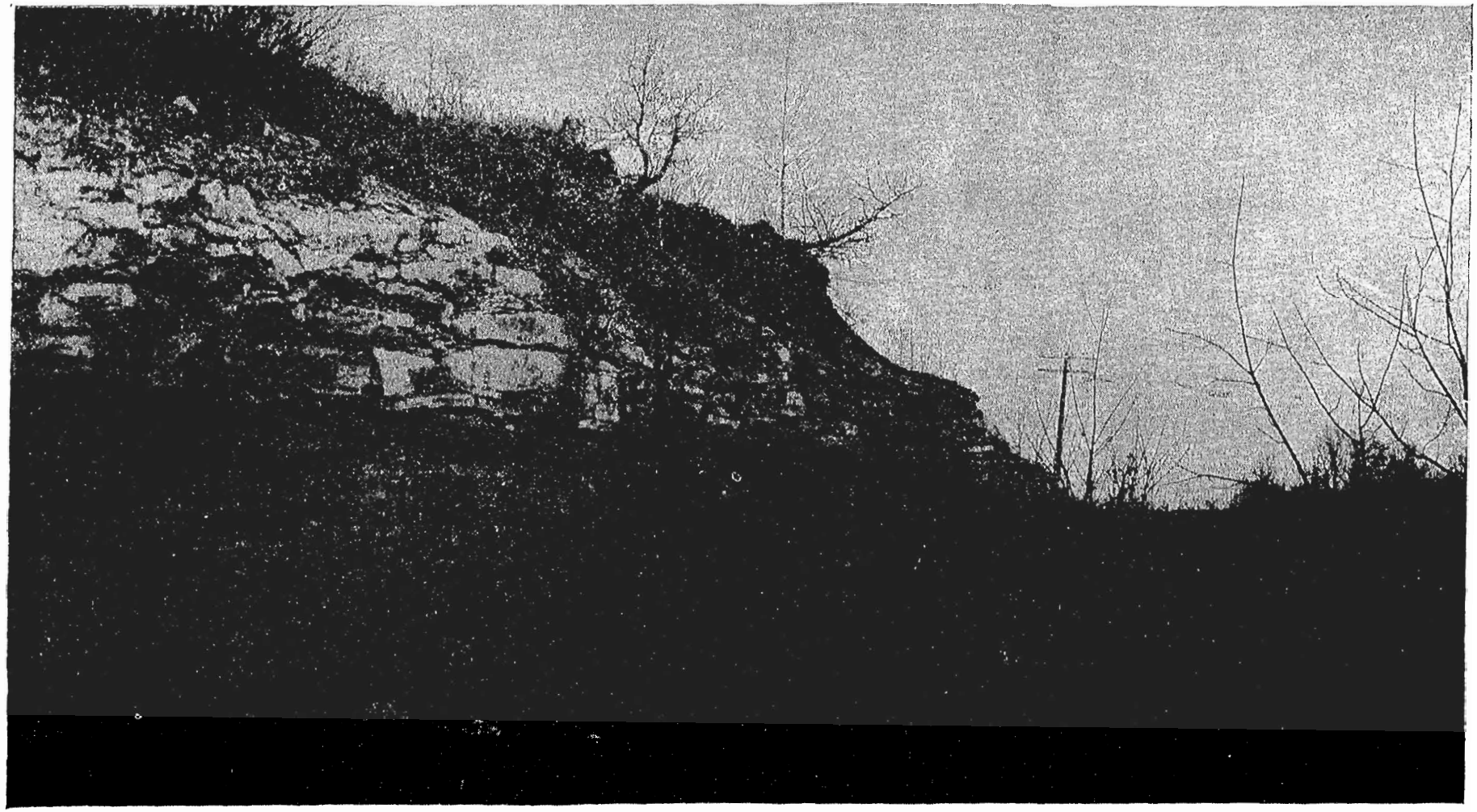
At Barney the Great Western track is more than fifty feet higher than at Peru, and west of there it ascends to the top of the bluff. About two miles east of Barney the Winterset rock has been cut through by the road, and in the bank of Clanton creek the Earlham layers are exposed. Quarries could be opened here with the minimum of track expense and with very little stripping. While the rock exposed is not to any great extent suitable for dimension stone it is excellently adapted for concrete, and a considerable amount of rubble could be obtained. Some dimension rock is exposed, and it seems probable that the Winterset beds, which are mainly talus-covered, would warrant opening.

### EARLHAM DISTRICT.

*Robertson quarry.*—When the state capitol was being built at Des Moines the limestone around Earlham was opened up at a number of points. The principal of these old quarries was located northeast of Earlham on Bear creek. They have long since been abandoned, and ledges nearer the main line of the Chicago, Rock Island & Pacific railway are now worked. The rock as seen in some of the older workings on the north side is shown in plate ix. The main quarrying is now, however, carried on on the south side.

A section near the middle of the quarry shows the following:

| | | FEET. | INCHES. |
|---|---|---|---|
| 9. | Stripping | 10 | |
| 8. | Limestone, soft, disintegrated, with geest in the crevices | 4 | |



EARLHAM LIMESTONE IN OLD QUARRIES NORTH OF THE RAILWAY.

| | | FEET. | INCHES. |
|---|---|---|---|
| 7. | Limestone, compact, massive, bluish | 1 | 6 |
| 6. | Shale, drab, calcareous | | 4 |
| 5. | Limestone, compact, bluish, in thin ledges | 3 | |
| 4. | Shale, bluish, with very many *Clionetes vernculianus* | | 4 |
| 3. | Limestone, compact, blue | 2 | |
| 2. | Shale, blue, calcareous | 1 | |
| 1. | Limestone, ashen, thick to thin layers | 10 | |

But little dimension rock is taken from the quarry. Some of the stone is used for foundation and retaining walls, but

FIG. 79. A portion of the Robertson quarry east of Earlham, showing a typical exposure of Earlham limestone.

most of it is crushed. The stripping is done by hand. Very little blasting is necessary to loosen the rock. The stone is hauled to the crusher in tram cars of about one cubic yard capacity, and hoisted and dumped by tail rope. The plant includes a forty-horse power steam plant, one Gates crusher, elevator and revolving screen. The screen takes out all

material less than three-eighths inches in diameter, the fine material being used by the railway for yard filling at Valley Junction. The coarser rock is used mainly for concrete at Des Moines, and brings $1.30 per yard. The plant has a capacity of about 200 yards per day.

*Earlham Land Co.*—The quarries of this company are located south of town, in the valley of North river, and are illustrated in plate x. As has already been stated, the beds opened up are the equivalents of those found at the Robertson quarry. There is, however, an overlying shale not found at the latter place.

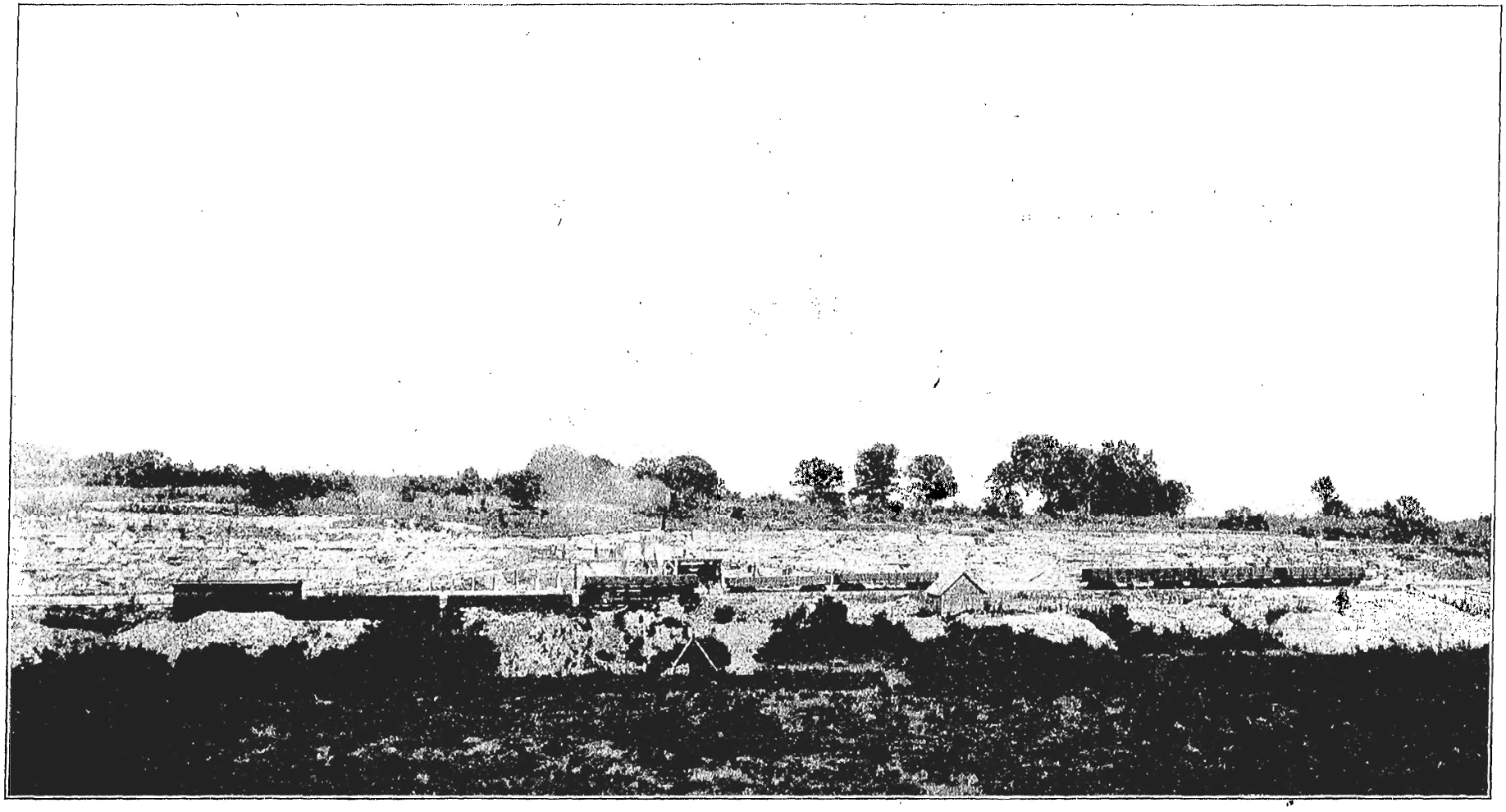
The rock is cut by a series of joints, some of which have spread till there is an open space of as much as seven inches. These crevices are sometimes filled by stalactitic matter, which usually coats merely the sides, but in places the crevices are completely filled. The presence of the joints and bedding planes makes the quarrying easy, and very little powder is used. As at the Robertson quarry most of the rock is crushed, though some good dimension stone could be obtained. The crushing plant includes a Gates crusher, tail rope, screens and steam plant. The capacity is 150 to 200 cubic yards per day, and the quarry employs about thirty men. The output is shipped on a switch from the Chicago, Rock Island & Pacific railway.

*Nevitt quarry.*—This is a local quarry opened some years since a mile southeast of Earlham. It supplies an important local trade.

*Eureka quarry.*—This quarry, formerly known as the McGorrisk, is a mile and a half south of Earlham (Tp. 77 N., R. XXIX W., Sec. 18, Nw. qr., Se. ¼). It is not worked at present.

## WINTERSET DISTRICT.

There are numerous quarries in and near Winterset, though none are very extensively worked at present. The Clark quarry north of town (Tp. 76 N., R. XXVIII W., Sec. 25), is opened in the Earlham beds. In the southeastern portion of



QUARRY AND CRUSHER OF THE EARLHAM LAND CO.

the city both the Winterset and the Earlham beds have been opened up. In the city quarries the former ledges show about fifteen feet of rock. The lower courses may be used for dressed stone, though they are not easily quarried nor are they generally worked. Good rubble and crushing stone is abundant. On the Arnold place the Earlham stone has been opened up, and was for some years burned into lime at the Cooley kiln. South of Winterset the Brown quarry (Tp. 75 N., R. XXVIII W., Sec. 1, Sw. qr., Se. ¼) was reopened in 1893, and has since furnished considerable curbing stone. The old Kipp quarry, near by, is not now worked. Extensive quarries were formerly worked in the Winterset beds about a mile farther south (Tp. 75 N., R. XXVIII W., Sec. 12, Nw. qr.). It was from these quarries that a portion of the stone for the court house was taken. The pillars and much of the cut stone came from the Backbone quarries (Tp. 75 N., R. XXVIII W., Sec. 16, Ne. qr., Se. ¼). The section at this point has already been given in connection with the description of the limestone.

At the Backbone the heavy ledge at the base of the Fusulina limestone is well shown. It is known to the quarrymen as the magnesian ledge, though several different ledges in various parts of the county are confused under that term. It yields an excellent grade of stone. Higher portions of the Fusulina limestone are exposed in sections 22 and 23 of Webster township. It seems probable that the Fusulina stone, when properly opened up, will be found to yield some of the best rock in the county.

### PERU DISTRICT.

In the tops of the hills at Peru the Fusulina rock crops out and is quarried at several points on the west side of the stream. At the Reed quarry from ten to fifteen feet of stone are found, it being for the most part fine-grained and breaking with a conchoidal fracture. The lower portion, four to five feet thick, is heavily bedded and shows some twelve to four-

teen-inch stone. Above this heavy stone is a six-inch bed of shale over which is a thinner bedded, much jointed rock. It furnishes four, six, eight and some twelve-inch stone. Some of the rock is fine-grained and of almost lithographic texture, but is too much cracked and seamed to be of value for dimension work.

The lower beds, including the Winterset, Earlham and Fragmental, have not been opened up, though they show in the hills. About two miles east of Barney the Winterset rock has been cut into by the railway, though the ledges are now largely covered with talus. The blocks exposed show thicknesses of six and eight inches. Below the limestone (1,020 A. T.) the usual black shale is exposed. Along the creek near by, at the proper level below this shale, the Earlham beds are shown and exhibit the following section:

| | | FEET. | INCHES. |
|---|---|---|---|
| 4. | Limestone, thin, shaly, grading into calcareous shales | 4 | |
| 3. | Limestone, coarse, made up of shell fragments, rather heavily bedded, ranges up to fourteen-inch rock, good quality | 5 | |
| 2. | Shale, calcareous, gray, *Chonetes verneulianus* abundant, *Spirifer cameratus* rare | | 6 |
| 1. | Limestone, thin and irregularly bedded, ledges of six inches and less, stone apparently argillaceous, with dull earthy fracture; carries *Chonetes verneulianus, Spirifer cameratus, Productus nebrascensis, Productus costatus, Productus cora, Athyris subtilita, Meekella striatacostata* and corals; ledges capped by a ten-inch layer of coarse gray rock made up of finely comminuted shells | 6 | |

The only quarry in the vicinity is that of Mr. Irains, where about five feet of stone suitable for dimension work is obtained with very little stripping. In Mr. Irains' house, built of the product of this quarry, the good qualities of the stone may be seen.

ST. CHARLES–TRURO DISTRICT.

Near St. Charles the thin ledges of the Fragmental rock already described are quarried locally. The total thickness of stone is about two and one half feet, the ledges running from four to six inches. Thicker ledges probably occur higher in the hill, but have not been opened up. The quarries at St. Charles marketed last year about thirty perch of stone at 75 cents a perch. Equivalent ledges have been opened southwest of St. Charles.

### Road Material.

The matter of good roads is deservedly attracting attention within the county. The considerable portion of the area not reached by railway lines makes wagon hauling more than usually important. To reach a market or to go to the county seat, requires in many cases a drive of ten to twenty miles. A portion of this drive is almost certain to be over very rough roads. The distribution of the drainage and the resultant configuration of the topography causes the north and south roads of the eastern and central portion of the county to be necessarily rough. The considerable relief and the flat topography of the uplands make steep grades at the river crossings almost unavoidable. The grades could be much bettered if the roads had been located with reference to the topography rather than the land lines, but here, as was usual in the Mississippi valley, the necessity for wholesale methods in the rapid settling of the country made deliberation impossible, and it must be the work of the future to correct some, at least, of the mistakes of the past.

The east-west roads chancing to follow drainage lines or the interdigitate divides, have in the main avoided steep grades. Some of the principal lines of travel are, so far as this factor is concerned, excellently located. The north-south roads of the extreme western portion of the county have also, in general, relatively few steep grades. It is not, however, altogether a matter of grades that is provoking here, as else-

where, a good roads agitation. The character of the roadway, be the grade ever so good, may be, and often is, so bad as to make the road quite impracticable at certain seasons. During good weather the roads are beaten hard, and in time are worn smooth; but in the spring, when the frost leaves the ground, many of the roads can be traversed only with the lightest loads. This condition obtains on some of the poorer roads almost the year round. The stiff undersoil of the loess on the uplands, the blue clay of the till, the geest, and much of the alluvium, all of which enter largely into the material forming the surface of the roadways, are predominantly impervious. They are usually, also, notably plastic. They prevent free drainage, and yet form a surface of black, sticky mud which adds greatly to the traction.

The improvement of the roads will necessitate, aside from the matter of location, adequate drainage and surfacing with road metal. More care in the building of the roadways so as to provide the necessary drainage is perhaps the first requisite. For road material the main reliance must be the limestone. Gravel beds of any importance have not been found in the county and probably do not occur, since the Wisconsin, the main gravel-forming ice sheet, did not reach so far south as either to enter the county or cross the headwaters of its streams. The earlier gravel-forming period which followed the pre-Kansan drift has left no traces in the county so far as can be discovered. The streams have not, by their own work, accumulated gravel beds to any considerable extent.

Limestone, however, occurs abundantly throughout most of the county. Some of the worst roads are along the foot of limestone cliffs. Rock could be obtained along most of the main roads readily and cheaply. It has already been used to a limited extent with excellent results. It is crushed in large quantities for the Des Moines market, being used for concrete, and is excellently adapted for macadam.

In stone for macadam two qualities are important: First, it must be sufficiently hard to resist too great wear, and Second,

it must be of such a nature that it will cement rapidly. The matter of hardness is relative only. Rock used in pavements exposed to continuous wear under heavy loads, must be able to resist considerable crushing strains; but for country roads, where the wear is relatively slight, this factor is of less importance. The limestone of the county, while it will of course crush under the wheels and will ultimately wear out, is not apt to prove particularly troublesome in that regard.

A macadam pavement derives its good qualities from the fact that the stone, under the roller or the wheels of traffic, breaks up and yields a fine dust, which with water forms a cement, binding the whole together. In effect a macadam pavement is a cheap concrete in which the bond is derived from the finer portions of the crushed rock. Not all stone, not even all limestone, will furnish a dust which has the requisite cementing properties. In some cases it has proven necessary to cover a macadam roadway with a thin surface of crushed iron or other material in order that the whole should be made to set. The limestone found in Madison county needs no such surface material. It is quite pure and dissolves under the action of surface water with relative rapidity. The dissolved material is frequently redeposited, not far from the point of solution, in the form of stalactitic matter. As was noted in the description of the quarry of the Earlham Land Co., this redeposition is locally important. The redeposited stalactitic matter forms a firm cement, holding together any pieces of rock which may be imbedded in it. Upon the roadway an analogous process takes place, and under proper conditions the recemented rock will form a firm and durable pavement.

The amount of stone necessary for covering a roadway will vary somewhat with the conditions as to foundation, grade, traffic, etc. Upon a properly drained and rolled foundation six inches of stone should be ample for most of the roads of the county. Upon this basis about 1,500 yards per mile would be necessary for a roadway fifteen feet wide. Stone is now being

furnished in Des Moines at $1.30 per yard, but this price could be very materially lessened in case the county crushed its own stone. The expense of grading and rolling the foundation, with that of delivering and spreading the stone would vary with the locality. In New Jersey certain roads are costing about $3,000 per mile. It is probable that the main roads of Madison county could be improved at an average amount considerably less than that sum; perhaps $1,000 to $1,500 could be taken as a fair estimate. To obtain the best results the work would need to be carried on according to a systematic plan, so that the work done each year should be a permanent improvement—a part of a single larger piece of work. The road work now carried on is essentially of a makeshift character. If to the amount of the road tax now annually expended were to be added the aggregate cost of breakdowns, undue wear on horses and vehicles, loss of time due from the light loads hauled, and losses due to inability to market produce rapidly when prices are most favorable, the relative cost of present and improved roadways would appear in the reverse of their present order.

### Lime.

The limerock found in the county can be burned to a lime, but the quality of the latter is not of the best. Curiously enough it is not the purest limestones which make the best lime, but those which contain a certain percentage of magnesia—the dolomites and magnesian limestones. For the most part the limestones of the county contain little magnesia. The lime formed from it is white, but is quick and heats rapidly. In slacking it must be handled very carefully and an abundance of water kept on hands. Lime was formerly burned at Winterset, Peru, in section 32 of Jefferson township, and section 9 of Madison township. At present there are no kilns in operation, and it is quite unlikely that kilns will ever be established except for local trade.

### Clays.

The abundance of stone and the nearness of the large brick works at Van Meter and Des Moines have prevented the development of any important clay industry in the county. The loess, which is everywhere present, and most of the alluvium found along the streams could easily and cheaply be made up into standard building brick. Only the simplest processes, those of the hand yard, would be necessary. Much of the loess could be made to yield better grades, including stock and face brick, if treated either as a stiff-mud or on a dry-press. In the eastern portion of the county where the Des Moines formation crops out, shales suitable for a considerable variety of products occur. So far they have not been utilized, the only brick now manufactured in the county being made from top soil and loess.

At Winterset there are two brickyards, both without machinery. The T. F. Mardis yard is one mile east of town (Tp. 76 N., R. XXVI W., Sec. 32). Two kilns of 100,000 to 150,000 capacity are ordinarily burned each season. In addition to brick of the usual size, brick twelve inches long are turned out. Southwest of town (Tp. 75 N., R. XXVIII W., Sec. 1) is the brickyard of W. D. and Joel Clark. They maintain two up-draft kilns of 25,000 capacity each for burning brick. At Earlham small quantities of hand-made brick have been made from the loess.

The wide distribution of the loess and the ease with which it can be worked up into brick and draintile upon the inexpensive auger machines, would seem to warrant investment in a plant. The stronger under loess which has given trouble in the hand yards will be found excellently adapted to the manufacture of drain tile, though it must not be dried too rapidly.

### Water Supply.

The numerous streams throughout the county adapt it excellently to stock farming. When water is needed for household or industrial purposes it is usually obtained from

wells at shallow depths. The base of the loess and the base of the drift are common water horizons. Water may, however, be found in gravel pockets at almost any level in the drift. The different shale horizons in the Missourian usually furnish water and their outcrops are marked often by lines of springs or water seepage. Water, though not usually of the best quality, is readily obtained from the Des Moines beds. In Jefferson township (section 36) Mr. C. D. Fletcher has a well 268 feet deep ending in a sandstone that lies near the base of the Des Moines. The following analysis of the water, by Dr. Floyd Davis, is published by the courtesy of Mr. Fletcher.

| | |
|---|---|
| Total solids | 5,580 |
| Loss on ignition | 1,800 |
| Chlorine | 497.5 |
| Free ammonia | 1.76 |
| Albumenoid ammonia | Trace |
| Nitrogen in nitrites | None |
| Nitrogen in nitrates | None |

"These results show that this is a highly mineralized water. The salts in it are principally sodium chloride (common salt). There are no poisonous substances in it. The salts present are really beneficial constituents of a mineral water; the commoner salt acting as a mild tonic, and the glauber salts as a strong cathartic. The sanitary analysis shows that this water is almost entirely free of organic matter, such as might come from drainage, and there are no reasons whatever why this is not a good water for domestic use and for stock."

## Water Power.

The rapid fall of the large streams of the county where they cross the Bethany limestones affords many excellent water powers, few of which are at present utilized. In former days there were several mills, the most famous, perhaps, being the tunnel mill at the Backbone. At this point, by means of a tunnel a few hundred feet long, water is

drawn from the river above the Backbone and a head of nearly twelve feet obtained.

North river Middle river, Clanton creek, and many minor streams cross the Bethany limestone. In each case there is a total fall of about eighty feet. This is distributed somewhat, but as each of the four benches of limestone is crossed there is usually a fall of ten to twenty or even more feet. Such water power may well become quite valuable, and it is not improbable that the future will see an important milling industry founded on it.

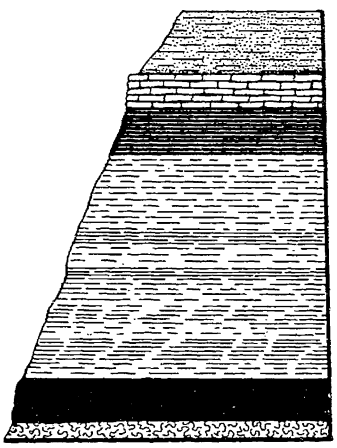
## Coal.

While Madison county lies within the limits of the coal measures there are at present no mines of more than local importance. The Missourian formation, which covers so large a portion of the area is practically barren. The only coal beds of importance known to occur in this formation are found in beds that lie above the divisions of the Bethany limestone outcropping here. The black shale horizons noted in the general section of the formation carry some impure coal, but neither in quantity nor quality is it important.

The upper portion of Des Moines formation, as exposed along the Raccoon river, contains three horizons along which coal has been generally found. Two of these coal horizons have been named respectively the Lonsdale and the Marshall, and between these is an intermediate horizon to which no name has been given.

This intremediate coal appears on Bulger creek in Jefferson township, Madison county. Coal was formerly worked in Madison township (section 25) and it is not improbable that it belonged to the Lonsdale horizon. The coal found in Crawford township, on Cedar creek (sections 17 and 18), south of Patterson (section 32) and southwest of Bevington (section 36) can not be definitely correlated. Coal horizons have been noted in the sections near St. Charles, and similar beds occur at approximately the same levels along Clanton Creek and Middle river.

All these coal beds are quite thin. In many cases only a little impure coal is mixed with the black shale. The thickest beds noted include that reported at the old Clarke mine (Tp. 77 N., R. XXVIII W., Sec. 25, Nw. qr.) and that south of Patterson (Tp. 76 N., R. XXVI W., Sec. 32, Ne. qr., Sw. ½). At the Clarke mine the bed is said to have been two feet thick. White gives the following section:

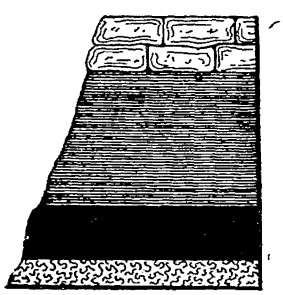


| | | FEET. |
|---|---|---|
| 6. | Shale, sandy | 32 |
| 5. | Limestone, impure, bluish | 2 |
| 4. | Shales, black, bituminous | 3 |
| 3. | Shale, argillaceous, bluish | 14 |
| 2. | Coal | 2 |
| 1. | Fire clay | 1 |

FIG. 80. Coal at Clarke mine.

The coal would seem from this section to represent the Marshall horizon. It is not now exposed.

The section south of Patterson is as follows:



| | | FEET. | INCHES. |
|---|---|---|---|
| 4. | Limestone, gray, compact, fossiliferous | 1 | |
| 3. | Shale | 2 | 6 |
| 2. | Coal | 2 | |
| 1. | Fire clay | | 6 |

FIG. 81. Coal bed near Patterson.

The mines of Madison county are small, and are worked only in the winter to supply the local trade. Some coal is obtained by stripping and some by drifting. No deep shafts have been sunk, and no extensive prospecting has as yet been undertaken. Thick, workable beds probably occur within the county, but at some depth beneath the surface. At Van

Meter, just outside Madison county, two veins have been worked. One lies 285 feet below the surface, which is 884 A. T., and the other about twenty feet below. Each vein averages about three feet in thickness. In Guthrie thick coal has been found at several points at equivalent levels below the Bethany limestone. In Polk, Marion and Monroe counties coal is taken from horizons which are below the beds of Madison county. How far west along these horizons the coal will prove thick enough for mining is an open question, and can only be solved by drilling. At Peru, in 1887, the Chicago Great Western railway put down a hole to a depth of 303 feet. At 212 feet a thin bed of coal is said to have been encountered. This is about the horizon at which the coal worked at Commerce should occur if present. There are thin coal beds worked in Warren county, the uppermost passing beneath the bed of Middle river close to the east county line. This horizon usually shows sixteen inches of coal. Forty-five feet below is a horizon showing coal of equal thickness, and thirty-five feet still deeper is a horizon with eighteen inches. Probably coal may be found along these horizons over a portion of the county. The beds have a general dip toward the southwest of three to four feet per mile, and seem to have been but little disturbed.

IOWA GEOLOGICAL SURVEY

# GEOLOGICAL MAP OF MADISON COUNTY, IOWA.

BY

J. L. TILTON

1897.

R. XXIX W. R. XXVIII W. R. XXVII W. R. XXVI W.

Tp 77 N.

Tp 76 N.

Tp 75 N.

Tp 74 N.

MADISON PENN JEFFERSON LEE JACKSON DOUGLASS UNION CRAWFORD WEBSTER LINCOLN SCOTT SOUTH OHIO MONROE GRAND RIVER WALNUT

Earlham Pitzer WINTERSET Webster Maple Grove P.O. Mc Bride Patterson Bevington St. Charles Harlev Old P.O. Wells Mc Pherson Peru East Peru Macksburgh Truro Gear P.O. Kasson Barney

CHICAGO ROCK ISLAND & PACIFIC — CHICAGO & ROCK ISLAND — CHICAGO & SOUTH WESTERN — DES MOINES

North River — Middle River — South River — North Branch — Middle Branch — South Branch — Cedar Creek — Honeyton Branch — Jones Creek — Great Creek — Grave Creek — Clanton Creek — Union Creek — Walnut Creek

## LEGEND

GEOLOGICAL FORMATIONS

MISSOURI

DES MOINES

INDUSTRIES

QUARRIES

LIME KILNS

CLAY PITS

MINES

DRAWN BY F.C. TATE